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CENTRAL INTELLIGENCE AGENCY
INFORMATION FROM
FOREIGN DOCUMENTS OR RADIO BROADCASTS

REPORT

CD NO. --

COUNTRY China

SUBJECT Transportation--Rail, turnaround time

HOW PUBLISHED Monthly periodical

WHERE PUBLISHED Peiping

DATE PUBLISHED Jun 1951

LANGUAGE Chinese

DATE OF INFORMATION 1951

DATE DIST. 28 Dec 1954

NO. OF PAGES 6

50X1-HUM

SUPPLEMENT TO REPORT

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SOURCE Jen-min T'ieh-tao (People's Railways), Vol III, No 6, 1951

A METHOD OF CALCULATING RR CAR TURNAROUND TIME IN CHINA

Chao Ching-hsing

Car turnaround time [TRT] means the elapsed time from one loading of a car to the next loading of the same car. Hence it embraces three components, the travel time, [TRVT], the switching time [SWT], and the stopping time [STPT]. Turnaround time is always expressed in terms of days and decimal fractions thereof; while travel time, switching time, and stopping time are expressed in hours and minutes. There are two formulas in common use, the Time-Count Formula, and the Car-Count Formula.

A. Time-Count Formula

Turnaround time is equal to the turnaround distance [TRD] divided by the travel speed [TRVS], plus the turnaround distance divided by the average kilometrage per switching occasion [SWD] multiplied by the average switching time, plus the work rate [WR] multiplied by the average stopping time. Expressed in a mathematical formula, using symbols, this formula becomes:

$$\text{TRT} = 1/24\left(\frac{\text{TRD}}{\text{TRVS}} + \frac{\text{TRD}}{\text{SWD}} \times \text{SWT} + \text{WR} \times \text{STPT}\right)$$

When reduced to simplified form, it is

$$\text{TRT} = \frac{\text{TCK} \div \text{TRVS} + \text{Total SWT} + \text{Total STPT}}{24 \times \text{DWL}}$$

$$\text{TRT} = \frac{\text{Total TRVT} + \text{Total SWT} + \text{Total STPT}}{24 \times \text{DWL}} \qquad \text{(A)}$$

B. Car-Count Formula

$$\text{TRT} = \frac{\text{Number of Cars in Operation [NCOP]}}{\text{Daily Work Load [DWL]}} \qquad \text{(B)}$$

We are of the opinion that neither of these formulas is absolutely correct, as we will attempt to show in the following analysis.

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1. The first of the two formulas, which calls for dividing the sum of the travel time, switching time and stopping time, by the daily work load, involves the following points that are worthy of consideration.

a. The kilometrage for the train is reckoned according to the railway divisions [geographical sections], but the kilometrage of cars picked up at way stations within the divisions is reckoned as one-half the length of the division, which is not the same as the actual distance from the pick-up station to the end of the division. Since the recording of the latter for all the cars thus picked up is impracticable, there is bound to be a lack of accuracy in the total turn-around distance as usually recorded.

b. Travel speed should be the speed of the cars; but the common practice has been to take the speed of freight trains only, and to take no account of cars making short runs when attached to mixed trains drawn by a single locomotive. Hence the figure used for travel speed is not exact, and therefore the travel time is inaccurate.

c. It is customary at marshaling stations to record the switching time in terms of hours as the unit, without noting the serial numbers of the cars, whereas the time of arrival and dispatch of trains is recorded in minutes as the unit. Therefore, as customarily recorded the switching time of cars differs from the actual switching time.

d. The distances that cars often have to be moved in marshaling yards causes the switching work to be dispersed over a considerable space, with the result that errors frequently creep into the statistical records. For example, at the Kirin station, cadres sometimes fail to record the time spent by cars outside of the yard limits, or one car may be recorded twice. But to investigate and confirm the correctness of the records of all operations every day is impossible.

2. In the Time-Count Formula, the number of cars in operation at 1800 hours each day is divided by the daily work load. Here the error is even greater. On the principle that two things equal to the same thing are equal to each other, place the second terms of both formulas together as an equation. Thus,

$$1/24\left(\frac{\text{Total TRVT} + \text{Total SWT} + \text{Total STPT}}{\text{DWL}}\right) = \frac{\text{NCOP}}{\text{DWL}}$$

That is, $\frac{\text{Total TRVT} + \text{Total SWT} + \text{Total STPT}}{24} = \text{NCOP} =$ the daily average number of cars in operation. But the daily average number of cars in operation is not equal to the number in operation at 1800 hours each day.

For the sake of simplifying the reasoning, suppose that the number of cars in operation at 1800 hours on a certain day does not represent the daily average number of cars in operation for that day in a particular railway bureau. Now, we know that the number in operation for the next day will be this latter number modified by the number of incoming and outgoing cars that pass the border stations of the bureau's territory, and by the number of cars that enter or leave the status of "cars not in operation." It will be realized that the net number is constantly changing and that a considerable change may occur quickly.

In a large territory where the number of cars in daily use is very great, it may be admissable to consider that the number of cars in use at a certain point of time properly represents the average number in use for a particular day or other limited period of time. (For instance, the number of cars in use in the whole country, is, for practical purposes, not affected by the comparatively small number of cars that enter from or depart to Korea.)

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However, in the case of a small territory, such as that between T'ao-lai-chao and Yü-shu in the Kirin Bureau, the degree of accuracy would be very low, for they have but one train a day in each direction. If at 1759 hours all of the "cars in operation" were to be dispatched to points outside of the territory, then according to the formula, the turnaround time would be zero.

But we know that the turnaround time cannot be zero. By neither of the two formulas referred to above, can the turnaround time be calculated with great accuracy. Can an accurate, yet simple, method be devised? The writer claims that it is possible, and such a method is based on a statistical principle by which the number of cars passing the border stations and the times of passing are combined without taking note of the serial numbers on the cars.

C. The Principle

$$\text{TRT} = 1/24 \left(\frac{\text{Total TRVT} + \text{Total SWT} + \text{Total STPT}}{\text{DWL}} \right) =$$

$$\frac{\dfrac{\text{Total TRVT} + \text{Total SWT} + \text{Total STPT}}{24}}{\text{DWL}} = \frac{\text{Daily average NCOP}}{\text{DWL}} \qquad (C)$$

Now if it is possible to ascertain correctly the daily average number of cars in operation, and divide it by the daily work load, then an accurate figure for turnaround time may be found. The unit used on the railways for train operations is the minute, so if we find the average number of cars in operation for each minute of the day, our problem is solved. Thus the equation last mentioned above, when put in terms of minutes would be thus:

Car turnaround time is equal to the sum of the number of cars in operation each minute divided by 1440 times the daily work load; or

$$\text{TRT} = \frac{\text{NCOP at Each Minute}}{1440 \times \text{DWL}} \qquad (D)$$

The number of cars in operation each minute is to be computed from the records as to the times and number of incoming and outgoing cars that pass the border stations and the times and number of cars that enter or leave the cars-not-in-operation status. Multiply the number of cars in operation at a given moment by the number of minutes in the interval during which no change in the number occurs. The product represents the number of car-minutes for that interval. At 1800 hours, total the figures for the intervals of the preceding 24 hours, divide this by 1440, and the quotient will be the average number of cars in operation for that day, weighted according to the length of time they were in operation in the territory of the subbureau. (See Table 1, below.)

If the subbureaus use the figure for daily average number of cars in operation thus derived to compute the turnaround time for their respective subbureaus, then the bureau need not itself make detailed calculations as to the number of cars in operation each minute, but needs only to total the average number for each day reported by each subbureau under its control. In the same manner, the Ministry of Railways may simply add together the figures of all the bureaus, and check that sum against the total number of cars in operation throughout the whole country. If the figures do not agree, it indicates errors in the statistical records or in the calculations.

D. Illustration

It may seem from the following illustration that this method involves more work than just dividing the number of cars in operation by the daily work load in order it find the turnaround time, as in formula (B) above. Actually, the men in the subbureau's train dispatching office who control the trains passing the border stations can easily record the time and number of cars passing, and complete the computations to show the cumulative number of cars in operation at any moment of the day. Within a very short time after 1800 hours these men could accurately calculate the turnaround time. I believe that if a subbureau, by using little more than 10 minutes, can ascertain accurate facts as to the transport accomplishments for that day, it is worthwhile.

In cases where the incoming and outgoing traffic is very heavy for a particular subbureau, its staff may use the same method as above, expect that they record the data for each hour, instead of each minute, and compute the cumulative number of car-hours, as in Table 2 below, and divide the total by 24 instead of by 1440. The formula would be

$$TRT = \frac{\text{NCOP for Each Hour}}{24 \times DWL} \qquad (E)$$

The latter formula and computations are much simpler than for Formula (D), but they are not as accurate.

To illustrate, let the daily work load be 400 cars. Using this figure and the data in Table 1, below, in Formula (D), we have:

$$TRT = \frac{693,027}{1,440 \times 400} = 1.20 \text{ days}$$

This figure, derived by the simple and accurate method proposed in this article, should be compared with that reached by using in the numerator of formula (B) the number of cars in operation at 1800 hours, as follows:

$$TRT = \frac{540.5}{400} = 1.35 \text{ days}$$

If Formula (E) is used, based on car-hours of cars in operation, using the data in Table 2, the computation is as follows:

$$TRT = \frac{12,154}{24 \times 400} = 1.27 \text{ days}$$

As to choosing which formula, (D) or (E), should be adopted, it is recommended, that both be used for a trial period as a check against each other. If they are found to agree closely, then Formula (E), the simpler of the two, based on car-hour records, may be used regularly to save time and effort. But if they do not agree closely, then it is preferable to use the car-minute method, Formula (D), because it is more accurate.

Table 1. Computing the Daily Average Number of Cars in Operation in a Subbureau, on the Car-Minute Basis

Explanation of Column Headings:

A The time of day, 24-hour system, when changes occur in number of cars.

B Length of interval, in minutes, during which no change occurs.

C Number of incoming cars passing border station.

D Number of cars coming in from a not-in-operation status.

E Number of outgoing cars passing a border station.

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F Number of cars going into a cars-not-in-operation status.

G Net number of cars in operation at the indicated time.

H Number of car-minutes of cars in operation during the indicated interval (B x G = H).

A	B	C	D	E	F	G	H
1800	35					522	18,270
1835	26	30				522	14,352
1901	81			29		523	42,363
2022	36	30.5				553.5	19,926
2058	74	24.5				578	42,772
2212	56			31.5		546.5	30,604
2308	32			29		517.5	16,560
2340	30			30		487.5	14,625
2410	123			28.5		459	56,457
0213	91	29				488	44,408
0344	106			30		458	48,548
0530	82			29		429	35,178
0652	109				5	424	46,216
0841	27	30.5				454.5	12,271
0908	20				5	449.5	8,990
0928	81		4			453.5	36,734
1049	103	30				483.5	49,800
1232	141			29.5		454	64,014
1453	39	29.5				483.5	18,857
1532	20				6	477.5	9,559
1552	10		4			481.5	4,815
1602	28			30		451.5	12,642
1630	42	29				480.5	20,181
1712	18	30				510.5	9,189
1730	12	30				540.5	6,486
1742	17			30		510.5	8,679
1759	1	30				540.5	541
1800	1,440						693,027

Table 2. Computing the Daily Average Number of Cars in Operation in a Subbureau, on the Car-Hour Basis

Explanation of Column Headings

AB Hour intervals.

C, D, E, F, G, are the same as in Table 1.

AB	C	D	E	F	G
Carried forward from yesterday					522
1800 - 1900	30				552
1900 - 2000			29		523
2000 - 2100	55				578
2100 - 2200					578
2200 - 2300			31.5		546.5
2300 - 2400			59		487.5
2400 - 0100			28.5		459
0100 - 0200					459

[redacted]

AB	C	D	E	F	G
0200 - 0300	29				
0300 - 0400					488
0400 - 0500			30		458
0500 - 0600					458
0600 - 0700			29		429
0700 - 0800				5	424
0800 - 0900	30.5				424
0900 - 1000		4			454.5
1000 - 1100	30			5	453.5
1100 - 1200					483.5
1200 - 1300					483.5
1300 - 1400			29.5		454
1400 - 1500	29.5				454
1500 - 1600					483.5
1600 - 1700	29	4		6	481.5
1700 - 1800	90		30		480.5
24 hours			30		540.5
					12,154

- E N D -

[redacted]